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Root Variations in the Teeth of Ancient People of Hadrianopolis

Variaciones de las Raíces en los Dientes de los Antiguos Habitantes de Adrianópolis

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SUMMARY: Dental variation, or nonmetric traits, are used by anthropologists to determine kinship relationships. The most common variations in tooth roots are dilaceration, filection, dwarf root, and number variations. In this study, root variations were investigated in human teeth obtained from the ancient city of Hadrianopolis, one of the most important anti-cities of ancient Anatolia. A total of 1426 teeth of human skeletons were macroscopically analyzed to determine the variations. Root variations in the community were divided into number and shape variations. Number variation was detected in a total of 10 teeth. Seven of these teeth belong to the mandible and three to the maxilla. Among the individuals with root number variation, 2 were male and 2 were female. The shape variations seen in Hadrianopolis society are flexion, root fusion, dwarf root and giant root variations. The root variations identified in this study will provide an important literature for future studies on ancient Anatolian populations.

KEY WORDS: Dental morphology; Hadrianopolis ancient city; Dental variations; Root variations.

INTRODUCTION

Nonmetric characters are morphological features that can occur in any anatomical tissue (Wilson, 2010). Terms such as discrete, non-metric, morphological, discontinuous, discontinuous, semi-continuous, threshold, small and secondary are used to describe features on teeth that cannot be measured (Scott *et al*., 2018). Nonmetric characters in teeth help anthropologists to determine kinship relationships (Fournier *et al*., 2022). Although nonmetric characters in roots are not as common as in crowns, they are used to distinguish between populations (Scott & Turner, 2015). The number of nonmetric characters identified in tooth crowns and roots is quite large. First, 29 nonmetric features were identified and classified by Turner. Today, more than 100 different variations have been identified, of which 30-40 crown and root features are well defined, standardized and subjected to detailed anthropological analysis (Scott *et al*., 2018). The most common variations in tooth roots are filection, dilaceration, dwarf root and number variations. Dilaceration is the sharp bending of the tooth crown or root (Enache *et al*., 2022). Flexion is known as the smooth curvature of the root. Short root anomaly, which is among the root variations, was first described by Lind as a dental disorder affecting tooth root development (Lamani *et al*., 2017). Root number variations are among the most common root variations. The standard root number for human teeth is as follows: Upper and lower incisors; 1, upper canines; 1, lower canines; 1 or 2, upper premolars; 1 or 2, lower premolars; 1 or 2, upper molars; 1, 2 or 3, and lower molars; 1 or 2 (Scott *et al*., 2015). The most common number variations in the roots of teeth; 2 roots of the lower canine and fusion of the roots of the upper first premolars are among the most common root number variations. The most rare root number variation is the 3 rooted upper premolars. When the lower first premolars have 2 roots, it is called "Tomes' root" and Tomes' root (Tomes, 1848) is used to refer to a situation where a mesio-lingual root cone exhibits an inter-radicular projection and forms an independent root (Scott *et al*., 2017). The maxillary first molar is usually a three-rooted tooth with four or five tubercles. The roots of the upper first molar are usually fused. Variations with 2 or 4 roots can also be encountered. However, it is rare to have 4 roots. Similarly, single-rooted or 3-rooted variations can be seen in the lower molars. The lower first molar usually has two roots, one mesial and one distal, and fusion of these roots is frequently seen. However, a 3-rooted lower first molar is a very rare variation. Turner 2nd (1971) used the term 3RM1 for this nonmetric character.

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MATERIAL AND METHOD

Material: The ancient city of Hadrianopolis lies around Budaklar Village, 3 km west of Eskipazar District center, parallel to the present Eskipazar-Mengen Highway (Laflı, 2008; Keles *et al*., 2011; Keles & Çelikbas, 2013). Hadrianopolis Ancient City studies have been carried out under the direction of Assoc. Prof. Dr. Ersin Çelikbas since 2020. The South Necropolis, where the skeletal materials that constitute the subject of the study were recovered, is located on a high rocky area 300 m south of the Church B building and 100 m southeast of the Hamam A building (Keles & Çelikbas, 2013). Excavations were carried out in the South Necropolis for a very short time in 2011, and extensive excavations were started in 2018. It was determined that the South Necropolis was used both during the Roman and Byzantine periods (Keles & Çelikbas, 2013).

A total of 1426 teeth belonging to human skeletons recovered between 2011 and 2022 constitute the subject of the study (Table I). The root variations in these teeth were tried to be determined macroscopically. The distribution of the teeth shows that 794 teeth belong to the mandible and 632 teeth belong to the maxilla.

Table I. Hadrianopolis Ancient City Dental Distribution (2011-2022)

Tooth Array	Mandibula	Maxilla	Total
I1	67	84	151
I2	88	67	155
C	110	99	209
P1	104	78	182
P2	82	64	146
M1	142	100	242
M2	152	92	244
M3	49	48	97
Total	794	632	1426

Method: Teeth from the ancient city of Hadrianopolis were examined macroscopically for root variations. The nonmetric characters detected in the tooth roots were analyzed according to the system standardized by the Arizona State University Dental Anthropology System (ASUDAS).

When the lower first premolars have 2 roots, it is called "Tomes' root" and Tomes' root is used to refer to the situation where a mesio-lingual root cone exhibits an inter-radicular projection and forms an independent root (Scott *et al*., 2017).

Turner *et al.* (1991), divided Tomes' root variation into 6 degrees (Fig. 1). According to this

0 Grade: There is no groove separating the cones on the mesial surface of the P1 root.

1 Degree: There is a slight V-shaped groove dividing the cone of the P1 root.

Grade 2: The V-shaped groove dividing the cones of the P1 root is deeper.

Grade 3: There is a deep developmental groove separating the root cones along at least of the root.

Grade 4: There are deep grooves on both the mesial and distal surfaces of the root.

Grade 5: The LP1 has two roots, a large buccal root and a smaller mesiolingual root, as the inter-radicular process is present.

The tome's root variation detected in Hadrianopolis is classified according to the grades mentioned above.

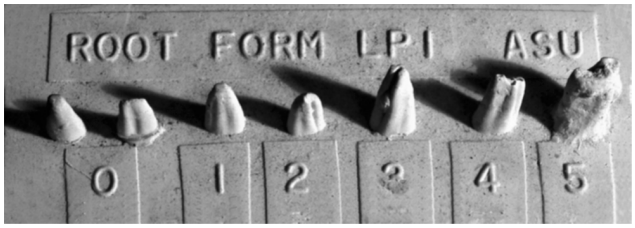

Fig 1. Tome's Root Classification (taken from Scott *et al*., 2017; Figure 38.1)

The most common root variation in the lower canine is a double root. An important anatomical variant of the 2-rooted mandibular first molar is the presence of an additional root in the distolingual region. Double-rooted canine teeth identified in the study were marked on the tooth form.

The root numbers of the lower molars were grouped (Fig. 2). Accordingly, A1 and A2 (lingual surface): radix entomolaris, B: M3 with radix entomolaris (lingual view) C: M1 with furcation root (buccal view), D: M1 with fused radix paramolaris (buccal view) (Gellis & Foley, 2021). The 3-rooted lower molars found in the Hadrianopolis community were classified accordingly.

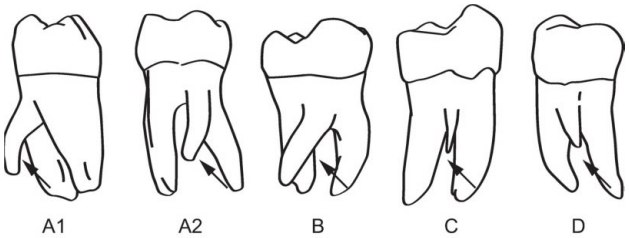

Fig. 2. Lower Molar root number variation (Gellis & Foley, 2021).

The extra root seen in maxillary first molars was first described by Thews *et al*. (1979) and Magnucki & Mietling (2021). Christie *et al*. (1991), classified the root number variation in the maxilla teeth into 3 groups according to root shape and degree, while Baratto-Filho *et al*. (2002) included

the 4th one in this classification (Magnucki & Mietling, 2021). Versiani *et al*. (2012), created their own classification. According to the classification made by Christie *et al* (1991); Type I maxillary molars have wide-angled, long and curved palatal roots and "cow horn" shaped cheek roots. Type II maxillary molars have four shorter, parallel and rounded roots. Type III maxillary molars are narrowed in root morphology and the mesio-buccal, mesio-palatal and disto-palatal canals are enclosed in a network covering the root dentin. Furthermore, Baratto-Filho *et al*. (2002), showed that the mesio-buccal and mesio-palatal roots were fused based on an endodontic case and proposed an additional fourth type (Type IV) (Magnucki & Mietling, 2021) (Fig. 3).

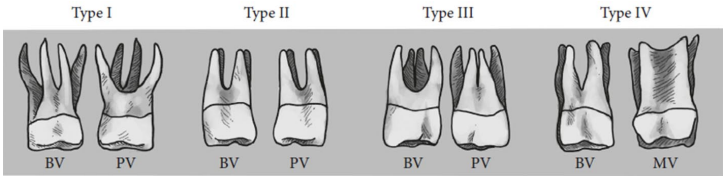

Fig. 3. Classification by Christie *et al*. (1991) (Magnucki & Mietling, 2021).

Versiani *et al*. (2012), examining four-rooted maxillary second molars with micro-CT, emphasized that Christie's configuration was not suitable and that the possibility of fusions in different areas should be taken into account, and defined a new Type III with wide-angled cheek roots with less angled and short palatal roots (Fig. 4).

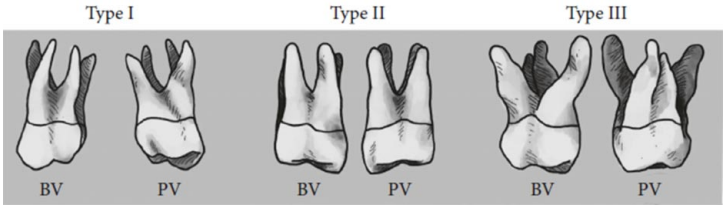

Fig. 4. Classification by Versiani *et al*. (2012) (Magnucki & Mietling, 2021).

RESULTS

In this study, the variations in the roots of the teeth of Hadrianopolis human skeletons were analyzed. Accordingly, the variations detected in the roots can be categorized under two headings: shape and number variations. Number variations are shown in Table II. Number variations were detected in a total of 10 teeth. Seven of these teeth belong to the mandible and three to the maxilla. Among the individuals with root number variation, 2 were male and 2 were female. The others belong to adult individuals whose sex could not be determined. Accordingly, it is seen that 1 of the 4 individuals with double roots is male and the others belong to adult individuals whose sex could not be determined. In terms of the number of teeth, double roots were detected in 3 right and 1 left canines. In the lower molars, 2 had 3 roots and 1 had 4 roots. One of the teeth with 3 roots was the lower left third molar and the other was the lower left first molar. The tooth with 4 roots was identified as the lower left first molar. In the maxilla, one of the teeth with 4 roots was the right third molar and the other was the left third molar. The 4 root variations detected on the right side were detected only on the alveolus and no teeth belonging to the jaw were found. The tooth with 2 roots is seen to be the upper right third molar.

Regarding the frequency of root number variations, the frequency of double roots in the lower canine is 5.08 % on the right and 1.96 % on the left.

The prevalence of Tome's Root is 5.55 % in male individuals. It was not found in female

Table II. Root (Number) variations in the teeth of the people of the Ancient City of Hadrianopolis.

Grave number	Individual Number	Sex	Age	Tooth Type	Variation
M-116 (2021)	Individual 2	Male	35-45 years	LRC	Double Root
M-104 (2021)	Individual 6	Female	Adult	LRC	Double Root
M-145 (2022)	Individual 13	Male	Adult	LRC	Double Root
M145	Isolated	Male	Adult	LLC	Double Root
M-24	Individual 10	Male	Elderly	LLP1	Tome's root (2th grade)
M-145	Individual 13	Male	Adult	LLP2	Tome's root (4th grade)
M-94		Isolated	Adult	LLP1	Tome's root (2th grade)
M-107 isolated	Individual 5	Male	Adult	LRM3	3 Root
M-113 (2021)	Individual 7	Male	35-45 years	LRM1	3 Root
M-94 Isolated	Individual 15	Child	Child	LRM1	4 Root
M-11 (2018)	Individual 11	Female	27-32 years	URM3	4 Root
M-94 (2020)	Isolated	Isolated	Isolated	ULM3	4 Root
M-74 (2020)	Individual 1	Female	Elderly	URM3	2 Root

LRC: Left Lower Canine; LLC: Left Lower Canine; LLP: Left Lower Premolar;URM1: Upper Right First Molar; ULM3: Upper Left Third Molar.

individuals. Tome's root was not detected in the lower right premolars, while it was found to be 5.55 % in the lower left premolars (Table III). One of the teeth with Tome's root was classified as Grade 4 and the other two as Grade 2 (Fig. 5).

Table III. Incidence of Tome's root by number of teeth

	n	k	%
Female	40	9	21,2
Male	22	1	0,37
Isolated	38	3	7,89
Adolescent	4	0	0
Total	104	13	12,5

n: number of investigated individuals; k: frequency of epigenetic features

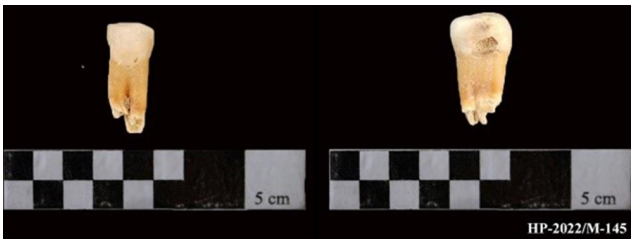

Fig. 5. M145 Tome's root (4th degree)

The incidence of 3-rooted lower molars (3RM1) was 1.3 % in the right teeth and no 3-rooted molars were found in the left teeth. The frequency of 4-rooted teeth in the mandible was 0.65 % on the right side and 0.65 % on the left side. In the maxilla, the frequency of 4-rooted molars was 0.87 % on the right side and 0.8 % on the left side. The frequency of 2-rooted molars in the maxilla was 0.87 % on the right side and no 2-rooted teeth were detected on the left side (Table IV). About 3RM1, Turner 2nd (1971) defined the 3rd root as a distolingual accessory root. A similar situation is observed in the Hadrianopolis sample. The 3RM3 in grave M107 is located as a distolingual accessory root (Fig. 6). Similarly, the accessory root in grave M113 is seen as a distolingual accessory root. According to the classification modified by Gellis & Foley (2021), among the 3-rooted teeth found in Hadrianopoliste, M107B, is included in group B (M3 radix entomolaris), while M133 is included in group A.

Fig. 6. M107-3RM3.

Table IV. Frequency of root number variations.

Variation	Right			Left		
	n	k	%	n	k	%
Double Root Canin	59	3	5,08	51	1	1,96
Tome's Root	50	0	0	54	3	5,55
3 Rooted molar (lower)	153	2	1,3	190	0	0
4 Rooted molar (lower)	153	1	0,65	190	0	0
4 Rooted molar (upper)	114	1	0,87	126	1	0,8
2 Rooted molar (top)	114	1	0,87	126	0	0

Upper molars have 3 roots located in the lingual, mesiobuccal and distobuccal. In some cases they may have 1, 2 or 4 roots. Two of the 4-rooted teeth were recovered from the multiple grave M 94. One of these teeth is the lower right decidous second molar (Fig. 7). The distal and mesial roots of the tooth are bifurcated towards the root tips. Another tooth recovered from grave M94 is the upper left third molar. The mesiobuccal root of the tooth is bifurcated towards the root tip, while the distobuccal root is shorter and smaller than the mesiobuccal root. The 4th root variation detected in the M11 female adult individual is the 3rd molar in the right maxilla. All the teeth in the mandible of the individual have fallen out and 4 root variations were detected from the number of alveoli. When the maxilla of the individual is examined, it is seen that the disto buccal root is bifurcated The upper third molar is classified into an additional fourth type, Type IV, based on an endodontic case by Baratto-Filho *et al*. (2002), who showed that the mesio-buccal and mesio-palatal roots were fused.

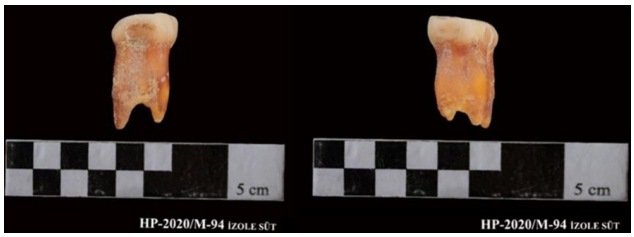

Fig. 7 M94 d4RM2.

The shape variations seen in the roots of Hadrianopolis individuals are shown in Table V. Accordingly, flexion, root fusion, dwarf root and giant root variations were observed in the community. Flexion is a shape variation that occurs when the roots are bent at a blunt angle in a softer manner (Standerwick, 2014). This variation was observed in the skeletons recovered from multiple graves M 94 and male individuals M121 and 107. The fused root variation, which is one of the most common shape variations, was found in a total of 10 teeth in 5 individuals. Dwarf root variation was seen in a total of 13 teeth in 5 individuals. Tome's root variation was seen in male individuals M24 and M145 and in a total of 3 teeth, including one isolated tooth (Table V).

Table V. (Root Shape) Variations frequency of occurrence.

Grave Number	Individual Nº	Sex	Age	Tooth Type	Variation
M-94	Individual 14	Isolated	Adult	ULC	Flexion
M-94	Individual 18	Isolated	Adult	URM2	Flexion
M-94	Individual 19	Isolated	Adult	URM2	Flexion
M-94		Isolated	Adult	ULM3	Flexion
M-121	Individual 13	Male	Elderly	LRM3	Flexion
M-43	Individual 8	Male	Elderly	URM2	Fusion Root
M-50	Individual 9	Female	Middle age	URM2	Fusion Root
M-50	Individual 9	Female	Middle age	ULM2	Fusion Root
M-84	Individual 4	Female	Adult	ULM2	Fusion Root
M-94	Individual 16	Isolated	Adult	URM3	Fusion Root
M-145	Individual 13	Male	Adult	LLM2	Fusion Root
M-145	Individual 13	Male	Adult	LRM2	Fusion Root
M-145	Individual 13	Male	Adult	URM1	Fusion Root
M-145		Isolated	Adult	URM3	Fusion Root
M-107	Individual 5	Isolated	Adult	LLP2	Giant Root
M-145	Individual 13	Male	Adult	URC	Giant Root
M-145	Individual 13	Male	Adult	ULC	Giant Root
M-84	Individual 3	Isolated	Adult	ULP2	Dwarf Root
M-84	Individual 3	Isolated	Adult	ULI1	Dwarf Root
M-84	Individual 4	Female	Adult	ULM2	Dwarf Root, Fusion Root
M-107	Individual 5	Male	Adult	LRM1	Dwarf Root, Flexion
M-134	Individual 12	Female	Middle age	URI1	Dwarf Root
M-134	Individual 12	Female	Middle age	ULI1	Dwarf Root
M-134	Individual 12	Female	Middle age	URC	Dwarf Root
M-134	Individual 12	Female	Middle age	ULP1	Dwarf Root
M-134	Individual 12	Female	Middle age	ULP2	Dwarf Root
M-134	Individual 12	Female	Middle age	ULM1	Dwarf Root
M-134	Individual 12	Female	Middle age	LLI2	Dwarf Root
M-134	Individual 12	Female	Middle age	LLM2	Dwarf Root, Fusion Root
M-94	Individual 17	Isolated	Adult	LRM3	Dwarf Root, Flexion

The prevalence of shape variations in the community was analyzed. Accordingly, the prevalence of Dwarf Root was found to be 4.16 % in female individuals and 2.78 % in male individuals. In terms of the number of teeth, it was found to be 2.12 % in female individuals, 0.37 % in male individuals and 0.52 % in isolated teeth. No dwarf root variation was found in adolescents, infants and children. In the general population, the prevalence of dwarf root was found to be 0.91 % (Fig. 8) (Table VI).

Table VI. Frequency of dwarf root (In terms of number of teeth).

Sex	n	k	%
Female	424	9	2,12
Male	269	1	0,37
Isolated	569	3	0,52
Adolescent	20	0	0
Baby+Chıld	144	0	0
Total	**1426**	**13**	**0,91**

Flexion is not seen in female individuals, while the incidence in male individuals is 5.55 %. In terms of the number of teeth, the prevalence was 0.74 % in male individuals and 0.88 % in isolated teeth. The prevalence of flexion root in the community was found to be 0.49 % (Table VII).

Table VII. Flexion Frequency (In Terms of Number of Teeth)

Sex	N	K	%
Female	424	0	0
Male	269	2	0,74
Isolated	569	5	0,88
Adolescent	20	0	0
Baby+Child	144	0	0
Total	**1426**	**7**	**0,49**

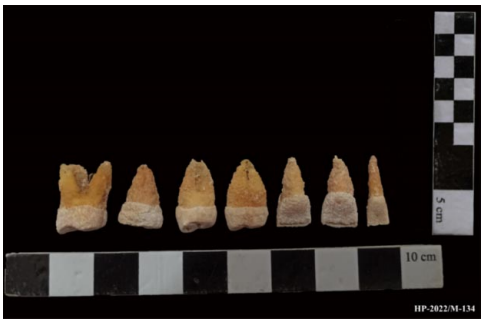

Fig. 8. Dwarf Root

DISCUSSION AND CONCLUSION

Studies of tooth root variation with an anthropological approach are very limited both worldwide and in Anatolian populations. In ancient populations, the majority of maxillary first premolars were single-rooted (75.2 %), even two-rooted premolars represented 24.8 %, while a three-rooted premolar was almost never observed (Fournier *et al*., 2022). In the skeletons excavated in the medieval cemetery of Saint Thibery, the incidence of 3-rooted premolars is 5.2 %. The rate of three-rooted first molars in this society was 2.2 %. When we look at the frequency of occurrence in today's populations, it is reported that it is seen over 25 % in Australian and South African populations, while it is detected between 1-10 % in American and Western Eurasian countries (Kararia *et al*., 2012; Dou *et al*., 2017).

3RM1 is one of the variations where geographic variation is most evident. In fact, the 3RM1 frequencies of North and East Asian populations are generally around 30 %. This percentage is also shared by Siberian populations and North American Eskimos. Their relatives, the Aleuts, have the highest 3RM1 frequencies worldwide, with 3RM1 frequencies sometimes reaching 50 %. Europeans and Sub-Saharan Africans rarely exhibit 3RM1, around 1 %. Southeast Asian and Pacific populations have a moderate frequency (5-15 %).

In European populations, this rate is around 3 % (Scott *et al*., 2017; Gupta *et al*., 2017). Although the etiology of 3RM1 is not fully known, it may be due to the formation of an additional root, external factors during tooth formation, or the inclusion of a recessive (atavistic) gene in the individual's genetic makeup and is thought to show a relatively higher level of genetic superiority (Erkman & Kaya, 2014; Gupta *et al*., 2017). The frequency of 3RM1 was reported to be 1.05 % in the Dilkaya population (Erkman & Kaya, 2014). They also reported that the prevalence of 3RM2 was 0.67 %, 3RM3 was 2.13 % and 3RM1 was 2.44 % (Erkman & Kaya, 2014). Erkman & Kaya (2014) reported that the prevalence of 3RM1 was 5.6 % in Neolithic period populations and 5 % in Iron Age populations. Alkan & Sagır (2019) examined three different populations, two from the Middle Ages and one from the present day, and found that the rate of three roots in mandibular molars was 3.4 % for the deciduous molars of the Van Kalesi Mound and 4.25 % for the Karagündüz population. The ratio of three roots in the secondary molars was 10.15 % for the Van Kalesi Mound population and 8.59 % for the Karagündüz population. In the Hadrianopolis population, the proportion of 3-rooted lower molars (3RM1) was 1.3 % in the right teeth and no 3-rooted molars were found in the left teeth.There is no mention of 4-rooted molars in ancient Anatolian populations. However, in the city of Hadrianopolis, the frequency of 4-rooted teeth in the mandible was 0.65 % on the right side, but not on the left side. The frequency of 4-rooted molars in the maxilla is 0.87 % on the right and 0.8 % on the left. The frequency of 2-rooted molars in the maxilla is 0.87 % on the right and 0.87 % on the left. The rate of 3-rooted lower molars in the ancient city of Hadrianopolis was 0.58 % when the right and left lower molars were evaluated together. When this rate is compared with other ancient Anatolian populations, it is seen that it is lower than Dilkaya, Van Kalesi Höyügü and Karagündüz. It was reported that the rate of flexion in Zeytinli Ada community was 15.98 % (Bekmez & Suata Alparslan, 2012; 49). This rate is lower (0.49 %) in the Hadrinopolis community. Root variation studies on ancient Anatolian populations are quite rare. Therefore, this study is important in terms of determining the stem variations of Ancient Anatolian populations.

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RESUMEN: Los antropólogos utilizan la variación dental, o rasgos no métricos, para determinar las relaciones de parentesco. Las variaciones más comunes en las raíces de los dientes son la dilaceración, la filección, la raíz enana y las variaciones numéricas. En este estudio, se investigaron las variaciones de las raíces en dientes humanos obtenidos de la antigua ciudad de Hadrianópolis, una de las anti-ciudades más importantes de la antigua Anatolia. Se analizaron macroscópicamente un total de 1.426 dientes de esqueletos humanos para determinar sus variaciones. Las variaciones de raíces en la comunidad se dividieron en variaciones de número y forma. Se detectó variación numérica en un total de 10 dientes. Siete de estos dientes pertenecían a la mandíbula y tres a la maxila. Entre los individuos con variación del número de raíces, 2 eran hombres y 2 mujeres. Las variaciones de forma que se observan en la sociedad Hadrianopolis son variaciones de flexión, fusión de raíces, raíces enanas y raíces gigantes. Las variaciones de raíces identificadas en este estudio proporcionarán una literatura importante para futuros estudios sobre las antiguas poblaciones de Anatolia.

PALABRAS CLAVE: Morfología dental; Ciudad antigua de Adrianópolis; Variaciones dentales; Variaciones de raíz.

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